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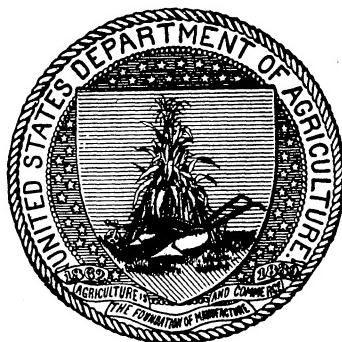
CEREAL BREAKFAST FOODS.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., February 20, 1906.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a summary of data on cereal breakfast foods prepared by Charles D. Woods, director of the Maine Agricultural Experiment Station, and Harry Snyder, professor of chemistry in the College of Agriculture of the University of Minnesota, in accordance with instructions given by the Director of this Office. For assistance in preparing the bulletin acknowledgment is made to Miss Helen W. Atwater.

For several years Professors Woods and Snyder have been studying the digestibility and nutritive value of cereal breakfast foods and related questions as a part of the investigations which they have carried on in cooperation with this Office. The results of their investigations are summarized in the present bulletin, together with other available data regarding this class of food products, which has assumed such great importance during recent years. In general, it may be said that while some of the claims made for many of the brands found on the market are extravagant, and the prices asked for some of the proprietary goods are high in comparison with the nutritive material furnished, yet cereal breakfast foods as a whole are wholesome and important articles of diet.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CEREAL BREAKFAST FOODS.

INTRODUCTION.

There is no part of the world except the Arctic regions where cereals are not extensively cultivated. From the oats and rye of the north to the rice of the hot countries, grains of some kind are staple foods.

An idea of the importance of cereal foods in the diet may be gathered from the following data, based upon the results obtained in dietary studies with a large number of American families. Vegetable foods, including flour, bread, and other cereal products, furnished 55 per cent of the total food, 39 per cent of the protein, 8 per cent of the fat, and 95 per cent of the carbohydrates of the diet. The amounts which cereal foods alone supplied were 22 per cent of the total food, 31 per cent of the protein, 7 per cent of the fat, and 55 per cent of the total carbohydrates—that is, about three-quarters of the vegetable protein, one-half of the carbohydrates, and seven-eighths of the vegetable fat were supplied by the cereals. Oat, rice, and wheat breakfast foods together furnished about 2 per cent of the total food and protein, 1 per cent of the total fat, and 4 per cent of the carbohydrates of the ordinary mixed diet, as shown by the statistics cited. These percentage values are not high in themselves, but it must be remembered that they represent large quantities when we consider the food consumed by a family in a year.

The reasons for such an extensive use of cereal foods are not hard to find. Besides being cheaply and easily grown, the grains contain unusually good proportions of the necessary food ingredients with a very small proportion of refuse. They are also readily prepared for the table and are palatable and digestible. Owing to their dryness they are compact and easily preserved without deterioration.

The grain as it grows on the stalk is surrounded by a hull or husk, which is so indigestible that it is removed before the seed is used for food. Each grain has an outer skin or bran layer, which may or may not be removed in milling. It is nearly always taken off from rice and buckwheat, sometimes from wheat, corn, and rye, and almost never from the other grains unless the outer sections are ground off

as in pearled barley. Grains simply hulled or husked and slightly crushed are called groats or grits; more finely crushed they are termed meal, and when ground into a fine powder and sifted they are known as flour.

Grains in the raw state are not usually considered pleasant to the taste and are thought to be difficult of digestion, and therefore cereals are almost always cooked before eating. The simplest and doubtless the oldest way of cooking them was by parching. This was frequently all that was done to the oats which the Scotch Highlanders took as their only provisions in their border forays, or to the corn the American Indians used for a similar purpose. But other ways of cooking make the grain more palatable, and it is usually mixed with water or other liquid and either baked as bread and cakes or boiled or steamed as pudding or porridge. It is the use of cereals as porridge that is of special interest, as cereal breakfast foods are most commonly used in America for porridge making or as a substitute for porridge. When used in this form they are perhaps not as convenient to eat as bread, do not keep so well, and require long cooking, but in spite of these disadvantages porridge is much used the world over, and grains have been thus cooked since earliest times. Many varieties of porridge are found. Sometimes the cereals are simply boiled in water, sometimes with milk, or with meat or kale, as in Scotch brose. Welsh budrum is made from oats which have been allowed to ferment and are then cooked, and the Arabs have a similar dish, kouskous, made from fermented wheat. In the old-fashioned bag puddings of England, of which Christmas plum puddings are the direct descendants, suet and fruit were mixed with wheat or barley and all steamed together in a bag. The simpler kinds of porridge are, however, the most common, and it is from them that modern cereal breakfast foods have been developed.

The number and variety of cereal breakfast foods at present on the market are large, but the majority of them fall readily into one of three groups. The first includes those which are prepared by simply grinding the grain, the second those which have been steamed or otherwise partially cooked and then ground or rolled, and the third those preparations which have been acted upon by malt, which induces a greater or less chemical change in the starch present.

No class of foods is more extensively or ingeniously advertised than the cereal breakfast foods. The claims sometimes made for them are astonishing. Some of them are said to contain several times as much nourishment as the same weight of beef; others are lauded as especially valuable as brain food or nerve tonics, and very many are claimed to be particularly well suited for persons of weak digestion. Many of these claims are obviously preposterous, others are doubtless true, and

still others contain an ingenious mixture of fact and fancy. Realizing that accurate information in regard to breakfast foods was needed, investigators at several agricultural experiment stations have recently studied their composition and food value, and it is now possible to make a number of definite and reliable statements about them.

GRAINS USED FOR BREAKFAST FOODS.

The grains ordinarily used in the United States for this class of foods are corn, oats, rice, and wheat; less commonly, barley; and in some sections wild rice. In other parts of the world millet, rye, buckwheat, Kafir corn, and other cereals are cooked into porridge, but with us they are too uncommon to warrant extended discussion.

Barley, which grows in almost any latitude, is more commonly eaten in Europe than in the United States, but less now than in former times. Its chief use in this country is for making malt, though pearl barley is frequently put into soups and a few barley breakfast foods are seen. Some of these last, however, are not made from barley alone, but from barley mixed with other grains.

Corn (maize) is a native American cereal, and although used extensively in Southern Europe and parts of the Orient, is still most widely used in this country. Since earliest times corn bread of various sorts, corn mush, and other corn dishes have been popular in the United States, the proportion of corn eaten being perhaps larger in the Southern States than in the North or West. There are many varieties of corn, differing in form, size, and color, but the average chemical composition in all cases is much the same. The germ of corn is relatively large and rich in fat, which tends to become rancid in keeping and is therefore sometimes removed in preparing the more popular meals. The names for the different corn products vary in different parts of the country. In some sections the whole kernels are called hominy and the partially crushed ones samp, while in others exactly the reverse is true. The old-fashioned hulled corn is sometimes called lye hominy. In making this the skin is loosened by steeping the kernels in a weak solution of lye, which gives a peculiar flavor to the product.

Oats are distinctively a cereal of northern regions, and wherever grown are an important porridge staple. In old-fashioned oatmeal much of the husk, which adheres closely to the grain, often remained in the meal. This seems now to have been largely remedied by improved methods of milling, though some tough particles of skin are still left in the finished product. Nevertheless, when thoroughly cooked, oats are a healthful food, the widespread use of which is well justified. The oat breakfast foods keep better than similar products made from wheat and corn.

Rice, as everyone knows, is a staple food in all tropical and sub-tropical regions and is much eaten elsewhere. The unhusked grain is usually called by the East Indian name of paddy. The husk and dark inner skin require special machinery to remove them. In the East new rice is considered inferior to old. All agree that it should not be eaten until three months after harvesting, and many consider it best after it is three years old.

Wheat is the most important breadstuff, and in the United States is also an important breakfast cereal. The old English dish, frumenty, made by boiling the husked grains with milk and spices, seems to be about the only one in which the grain is used whole. The slightly crushed grains with the bran left on are called cracked wheat or wheat grits. Wheat is also rolled or flaked, and is shredded by a special process. The majority of our wheat breakfast foods seem to contain at least a part of the middlings, farina and gluten preparations being the main exceptions.

Wild rice (*Zizania aquatica*), also called Indian and Canada rice and water oats, is a handsome reed-like water grass native in North America, found as far south as Texas and north into Canada, being especially common in the north-central United States and south-central Canada. The Indians have long used its seeds for food, gathering the crop and parching it to improve the keeping qualities and flavor. Their white neighbors, and especially sportsmen, have more and more followed their example until wild rice has become a well-known food in the regions where it is abundant and has found its way to many clubs and homes and is now seen on the menus of some fashionable hotels, where it is served not only with game but also as a special cereal dish. It gets its name from a very slight resemblance to real rice, the seeds being longer, thinner, and darker in color than the latter, and having a more pronounced flavor. It requires much longer cooking than ordinary rice.

PREPARATION OF MODERN CEREAL BREAKFAST FOODS.

Until recently, when the cereals were intended for porridge, they were, as a rule, simply husked and more or less crushed. Such products required long, slow cooking, and were hardly convenient for those who could not keep a fire all day. The earliest of the cereal breakfast foods which came into general use in the United States were of this class, oats being the most commonly eaten. Coarsely ground uncooked wheat does not seem to have been so generally used for preparing a breakfast dish, though corn meal and hominy have long been and still are popular. As the use of cereal breakfast foods became more common, the raw products were to a considerable extent replaced

by the so-called rolled oats and wheat, in which more or less of the cooking had been done at the factory, and these goods are commonly conceded to surpass the simpler old-fashioned raw products in ease of preparation in the household and in other ways. The manufacturers claim that the malted and otherwise specially prepared goods, which are a later development, represent a still further advance. These specially prepared cereals are usually sold in packages under proprietary names, which may or may not indicate their real nature. The methods of preparation vary greatly, and the exact details of processes are, of course, the secrets of the manufacturers. However, enough is known to give a fairly correct idea of the processes.

To begin with, the grains are usually very carefully cleaned. Ingenious devices have been invented for removing foreign seeds, dirt, and other substances which may have found their way into the grain. The husk or glumes of such grains as oats, barley, and rice are very thoroughly removed, so that the amount left in is much smaller than formerly.

Among the first of the modern preparations to be introduced were the "rolled" grains. To make these the husked grain is cooked for some time by steam and while still wet is run between rollers and pressed into thin flakes. After drying, the product is ready for marketing. Such rolled grains usually do not pretend to be more than partly cooked and are supposed to be thoroughly recooked before serving.

The ready-to-eat brands are prepared in a great variety of ways. Some are probably simply cooked in water and then dried and crushed; some are made of a mixture of different grains; some have common salt, malt, and apparently sugar, molasses, or other carbohydrate material added to them; some probably caramel or other similar coloring matter. Those with a flake-like appearance are made like rolled grains, save that the cooking is continued longer. Those which look like dried crumbs are probably made into a dough, baked, crushed, and browned. The shredded preparations are made with special machinery which tears the steam-cooked kernels into shreds and deposits them in layers or bundles. Very many of the ready-to-eat cereals are parched or toasted before packing. This gives them a darker color, makes them more crisp, and imparts a flavor which many persons relish.

In the so-called "malted" or "predigested" preparations malt or some similar substance is added during the process of manufacture. Malt, it will be recalled, is grain (usually barley) allowed to germinate until a ferment called diastase is developed, and then kiln-dried. This ferment, like some others, has the power, under certain conditions, of changing starch, which is insoluble in water, into various soluble

forms, such as dextrin, isomaltose, and maltose (sugar of malt). These soluble forms are more easily acted upon by the digestive juices than the original starch. How much starch is actually changed in the malted cereals and how desirable it is to have it so changed outside of the body are questions which are considered in a later section (p. 20).

Some of the cereal foods have apparently been cooked by dry heat only. In the case of puffed rice, which suggests popped corn somewhat in flavor and texture, it is said that the expansion of the grain is caused by heating it under pressure at a fairly high temperature and then suddenly diminishing the pressure.

In comparing the new cereal preparations with the old-fashioned ones we must not forget the neatness with which they are now put up. It was hard to tell what might have happened to some of the old brands. They were often ground from imperfectly cleaned grain, in small and inconvenient mills where it was hard to keep out dirt, and were very commonly sold from bins and barrels into which dust could easily find a way. In the modern mill cleanliness is found to be the best policy, and the neat, almost air-tight paper and cardboard packages in which the foods are sold are, as a rule, an assurance to the purchaser that they reach him as clean and fresh as they left the mill. In some of the manufactories the preparation of the cereal food seems almost perfection as regards cleanliness.

For convenience in transporting and handling, as well as to insure absolute protection from moisture and from air containing dust and germs, some cereal breakfast foods are marketed in sealed tin cans. The cans are evidently filled under pressure and consequently the cereals occupy relatively a small amount of space per pound. In provisioning camps, expeditions, etc., the small bulk and the fact that such goods can not be so readily damaged by water might prove an advantage.

NUTRIENTS AND ENERGY—TOTAL AND DIGESTIBLE NUTRIENTS IN CEREAL BREAKFAST FOODS.

Before discussing the chemical composition, digestibility, and nutritive value of cereal foods, it seems worth while to speak briefly of the general principles on which such a discussion must be based. The constituents of all foods, it will be recalled, are water, protein, fats, carbohydrates, and mineral matter or ash. Water, though needed in considerable quantities by the body, is obtained from beverages as well as from solid food and does not count as one of the nutritive materials or nutrients of food. It might be left entirely out of consideration in discussions like this save that its presence in food decreases the proportion of nutrients. Protein is the foundation of all the

tissues of the body and is an indispensable food ingredient. It is also the most costly of all nutrients. The carbohydrates include the various kinds of sugars and starches, commonly grouped together under the name nitrogen-free extract. Cellulose, or crude fiber, which forms the woody or straw-like framework of plants, also belongs to the carbohydrate group. It is here considered separately because, while the other carbohydrates are valuable nutrients, crude fiber is so indigestible that it has almost no food value. It is, however, undoubtedly useful in giving the needed bulk to the food. The fats include the numerous fats and oils in the diet, like those of butter, cream, fat of meat, olive oil, etc. Mineral matter or ash includes phosphates, chlorids, and other salts of calcium, magnesium, sodium, potassium, iron, etc.

The nutrients supplied in the food enable the body to grow and to repair its tissues as they are worn out in the necessary exercise of the body functions. Another of the great uses of food is to supply the body with the energy needed for its various activities and for keeping up body heat. During digestion, assimilation, and utilization food undergoes great chemical changes in the body, many of which liberate heat. It is through such chemical processes that the energy required for internal and external muscular work is provided and the body temperature maintained. Energy may be very conveniently measured in terms of heat, the calorie^a or heat unit being used for this purpose. It quite naturally follows that the amount of energy which the body gets from any food is spoken of as its fuel value. All the nutrients except mineral matters are sources of energy, but since protein, the only nutrient containing nitrogen, has tissue-building functions which the other nutrients do not possess, the body usually finds it more economical to use fat and carbohydrates largely as energy-yielding foods. As sources of energy fats are more concentrated than protein and carbohydrates, one pound of digestible fat supplying 4,260 calories of heat or energy, or about two and one-fourth times as much as a pound of protein or carbohydrates, which yields, respectively, 2,000 and 1,860 calories.

The terms digestion and digestible as commonly used frequently refer to ease or quickness of digestion or to the "agreement" of a given food with an individual. In physiological discussions "digestibility" more commonly refers to the thoroughness with which a food is absorbed—that is, the amount or percentage of nutrients retained by the body when food passes through the digestive tract. Digestibility may be determined by actual experiments or, when experiments can

^aA calorie represents very nearly the amount of heat required to raise the temperature of 1 pound of water from 0° to 4° F.

not be conveniently undertaken, may be calculated with reasonable accuracy by the aid of standard factors, which have been derived from actual experiments.

On page 18 the results of a large number of digestion experiments with cereal breakfast foods are summarized. These average values were used in computing the results given in Table 1, showing the average composition of various sorts of cereal breakfast foods, the proportion of digestible nutrients which they supply, and the energy value of the digestible nutrients. For purposes of comparison some other common foods are also included in the table. In this and other tables the different cereal breakfast foods are arranged in groups, but trade names are not used. If the housewife who is interested in any special brand will take note of its physical characteristics and appearance, she should be able to determine the class in which it should be included, and so decide as to its comparative value.

TABLE 1.—*Total and digestible nutrients and fuel value of cereal breakfast foods and some other foods.*

Kind of food.	Proportion of total water and nutrients in food.							Proportion of digestible nutrients in food.				Fuel value per pound.	
	Water.	Protein.	Fat.	Carbohyd-			Protein.	Fat.	Carbohydrates.	Ash.			
				Nitrogen-free extract.	Fiber.	Ash.							
Oat preparations:													
Oats, whole grain	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Cals.	
Oatmeal, raw	11.0	11.8	5.0	59.7	9.5	3.0	-----	-----	-----	-----	-----	1,767	
Oatmeal, raw	7.3	16.1	7.2	66.6	.9	1.9	12.5	6.5	65.5	1.4	1,767		
Rolled oats, steam-cooked	8.2	16.1	7.4	65.2	1.3	1.8	12.5	6.7	64.5	1.4	1,759		
Flaked and malted oats	7.9	16.2	5.2	66.7	1.6	2.4	12.6	4.7	66.3	1.8	1,709		
Flaked oats, to be eaten raw	8.6	13.1	7.8	68.8	1.7	10.2	7.0	66.7	1.3	1,742			
Wheat:													
Whole grain	10.5	11.9	2.1	71.9	1.8	1.8	-----	-----	-----	-----	-----		
Cracked wheat	10.1	11.1	1.7	73.8	1.7	1.6	8.1	1.5	68.7	1.2	1,501		
Rolled wheat, steam-cooked	10.6	10.2	1.8	74.1	1.8	1.5	8.5	1.6	70.7	1.1	1,541		
Flaked and crisped, ready to eat	9.4	12.2	1.4	72.7	1.9	2.4	8.9	1.3	67.9	1.8	1,500		
Flaked, crisped, and malted, ready to eat	9.0	12.1	1.4	73.0	1.8	2.7	9.1	1.3	68.4	2.0	1,526		
Shredded wheat	8.1	10.6	1.4	76.0	2.1	1.8	7.7	1.3	71.1	1.4	1,521		
Coarsely ground, parched at factory	8.0	14.2	3.1	72.3	1.0	1.4	11.5	2.8	70.1	1.1	1,699		
Crumbled and malted	5.6	12.2	1.0	77.6	1.7	1.9	9.1	.9	73.7	1.4	1,623		
Coarsely ground, decorticated	9.6	12.5	1.0	76.0	.5	.4	10.1	.9	78.1	.8	1,632		
Flaked, to be eaten raw	10.0	9.9	2.1	76.2	.8	1.8	7.2	1.9	69.3	1.4	1,500		
Farina	10.9	11.0	1.4	75.9	.4	8.9	8.9	1.3	72.9	.8	1,609		
Patent roller process flour	12.0	11.4	1.0	74.8	.3	.5	-----	-----	-----	-----	-----	1,650	
Entire wheat flour	11.4	13.8	1.9	71.0	.9	1.0	-----	-----	-----	-----	-----	1,675	
Graham flour	11.3	13.3	2.2	69.5	1.9	1.8	-----	-----	-----	-----	-----	1,670	
Rye:													
Whole grain	11.6	10.6	1.7	72.5	1.7	1.9	-----	-----	-----	-----	-----		
Flaked, to be eaten raw	11.1	10.0	1.4	75.8	1.7	7.8	1.3	71.1	1.3	1,526			
Barley:													
Whole grain	10.9	12.4	1.8	69.8	2.7	2.4	-----	-----	-----	-----	-----		
Pearled barley	11.5	8.5	1.1	77.5	.3	1.1	6.6	1.0	73.0	.8	1,514		
Flaked, steam-cooked	8.8	10.6	.8	77.7	1.2	.9	8.2	.7	74.0	.7	1,569		
Flaked, to be eaten raw	10.8	8.9	1.1	77.9	1.3	6.9	1.0	73.1	1.0	1,525			
Buckwheat:													
Flour	13.6	6.4	1.2	77.5	.4	.9	5.0	1.1	73.1	.7	1,471		
Farina	11.3	3.3	.8	84.6	.1	.4	2.6	.3	79.4	.8	1,480		
Groats	10.6	4.8	.6	83.1	.3	.6	3.7	.5	78.2	.5	1,503		

TABLE 1.—*Total and digestible nutrients and fuel value of cereal breakfast foods and some other foods—Continued.*

Kind of food.	Proportion of total water and nutrients in food.						Proportion of digestible nutrients in food.				Fuel value per pound.	
	Water.	Carbohydrates.					Protein.	Fatt.	Carbohydrates.	Ash.		
		Protein.	Fatt.	Nitrogen-free extract.	Fiber.	Ash.						
Corn:												
Whole grain.....	10.9	10.5	5.4	69.6	2.1	1.5	.....	.....	.....	.....	.....
Corn meal, unbolted.....	11.6	8.4	4.7	74.0	1.0	1.3	6.2	4.2	73.2	1.0	1,728	
Corn meal, bolted.....	12.5	9.2	1.9	74.4	1.0	1.0	6.8	1.7	74.6	.8	1,662	
Hominy.....	10.9	8.6	.6	79.2	.4	.3	6.4	.5	78.7	.2	1,671	
Flaked, parched.....	7.3	10.1	1.8	77.2	1.2	2.4	7.5	1.6	77.5	1.8	1,734	
Pop corn, popped.....	4.3	10.7	5.0	77.3	1.4	1.3	7.9	4.5	77.8	1.0	1,882	
Hulled corn.....	74.1	2.8	.9	22.2	.....	.6	1.7	.8	21.8	.4	492
Rice:												
Whole rice, polished.....	12.3	6.9	.3	80.0	.....	.5	5.8	.3	78.4	.4	1,546
Flaked, steam-cooked.....	10.2	8.3	.3	79.7	1.2	.3	6.9	.3	79.2	.2	1,595	
Puffed rice.....	7.1	6.2	.6	85.7	.....	.4	5.1	.5	84.0	.3	1,639
Popped rice.....	.7	8.6	.2	90.0	.....	.5	7.1	.2	88.7	.4	1,754
Wild rice:												
Whole grain.....	9.9	13.7	.9	72.7	1.2	1.6	.....	.....	.....	.....	.....
Parched.....	9.6	13.0	.9	74.0	1.1	1.4	10.1	.8	70.4	1.1	1,565	
Kafir corn:												
Flour.....	16.7	6.6	3.8	69.5	1.2	2.2	5.1	3.4	66.3	1.7	1,452	
Meal.....	16.1	11.2	.5	68.1	2.0	2.1	8.7	.5	65.8	1.6	1,426	
Bread, entire wheat.....	38.4	9.7	.9	48.5	1.2	1.3	8.0	.8	46.7	1.0	1,079	
Bread, Graham.....	35.7	8.9	1.8	51.0	1.1	1.5	6.8	1.6	47.4	1.1	1,081	
Bread, white.....	35.3	9.2	1.3	52.6	.5	1.1	8.1	1.2	52.0	.8	1,203	
Crackers.....	6.8	10.7	8.8	71.4	.5	1.8	9.1	7.9	70.5	1.4	1,905	
Macaroni.....	10.3	13.4	.9	74.1	1.3	11.6	.....	.....	72.2	1.0	1,660
Beans, dried.....	12.6	22.5	1.8	55.2	4.4	3.5	17.6	1.6	57.8	2.6	1,434	
Peas, dried.....	9.5	24.6	1.0	57.5	4.5	2.9	19.2	.9	60.1	2.2	1,487	
Potatoes, raw.....	78.3	2.2	.1	18.0	.4	1.0	1.6	.1	18.2	.8	369	
Beefsteak.....	66.0	20.3	13.6	.....	.....	1.1	19.9	12.9	.....	.8	950

Different specimens of the same grain show considerable variations in composition, depending upon such factors as the variety, the soil, the climate, and the season in which they are grown. The cereal breakfast foods and other materials prepared from the grains naturally show a corresponding range in composition, but in general are quite similar in composition to the grains from which they are made. The methods of hulling, milling, and manipulation to which the breakfast foods and similar goods are submitted naturally exercise some effect on composition. Thus, two specimens of oatmeal may vary in the amount of crude fiber which is left in the manufactured product, or one brand of rice or pearled barley may be polished down more thoroughly than another. It is believed, however, that the figures in the foregoing table, which are based on a large number of analyses, are representative, and that they show average values for various products as they are found in American markets.

The analytical data summarized in the table show that the grains and the products made from them, as is obvious from their appearance, are comparatively dry materials, the average water content of the uncooked material being not far from 10 per cent. The cereal

grains and their products have a fairly high protein content, but the carbohydrates, especially nitrogen-free extract, make up the nutrient group present in the largest proportion. The fat content, though never large, varies within rather wide limits, being greatest in corn and oats and their products and lowest in rice. The proportion of ash in cereals is small, as indeed is the case with all the common food products. Some variation is observed, the coarser grain products containing rather more ash than those made up of the interior portion of the grain. Such differences are, however, too small to be of much account in an ordinary diet, since the amount of ash constituents supplied will almost always be more than sufficient for all needs.

In comparing the composition of the different cereals it is apparent that while they resemble each other closely and all are rich in carbohydrates, there are certain differences between them which are quite characteristic. Thus, corn is characterized by a relatively high proportion of fat; oats are relatively rich in both protein and fat; rice is comparatively free from crude fiber and fat; wheat and rye have a high proportion of protein with a moderate amount of fat, while barley and wild rice contain about average proportions of all the nutritive ingredients. Judged by their chemical composition alone, that is, by the total amount of nutrients furnished, of the six most important cereal grains, namely, wheat, oats, rice, corn, rye, and barley, oats appear to furnish the nutrients in better proportions than the other cereals. Wheat ranks very close to oats and corn next to wheat.

The hulling and other processes followed in the manufacture of cereal breakfast foods frequently remove some of the crude fiber of the outer layers of the grain, and so many of the manufactured products contain less of this indigestible material than the original grain. In general, however, a comparison of the cereal breakfast foods and the grains from which they are made shows that the manufactured products are very similar in composition to the original grain. This is what might be expected when it is remembered that cleaning, milling, and otherwise manipulating the grains take little from them and add nothing to them, though such processes may and do modify materially the appearance, texture, and flavor.

When digestible nutrients are considered, the differences between the various cereal preparations are not more marked, and, as may be seen from the data in Table 1, the relative rank of the cereals is about the same as when they are compared on the basis of total nutrients. Thus, the oat foods contain the largest amounts of digestible protein and fat and their fuel value is highest. The wheat preparations, either plain or malted, rank next to the oats as regards digestible protein. The barley, corn, and rice preparations are much alike, both in

the amounts of digestible nutrients furnished and in the available energy which they yield. The table also shows that the quantities of nutrients digested from the breakfast cereals correspond very closely to the quantities digested in other cereal preparations from the same grains. Thus, wheat breakfast foods and macaroni supply about equal amounts of digestible material, as do also corn mush and corn bread. The so-called partially digested or ready-to-eat cereals seem to supply no more digestible material than the plain grains when well cooked.

Owing to the differences in the amount of water contained in the different classes of cereal foods, it is perhaps fairest to compare the uncooked breakfast cereals with flours and meals, and the ready-to-eat goods with such dry materials as macaroni and crackers, though these latter on an average contain a trifle less water than the breakfast foods. On such a basis it will be seen that hominy seems to contain a little more digestible protein and a little less digestible carbohydrates than corn meal, the differences being due perhaps in part to the method of preparation and in part to the kind of corn used. The wheat flours contain on an average more digestible protein and digestible carbohydrates than the wheat breakfast foods. Crackers are poorer in digestible protein and carbohydrates than the comparable breakfast foods, but usually contain so much added fat that their total fuel value is higher. Macaroni is very like wheat breakfast foods in composition and food value.

If any of these foods are compared with meats it will be seen that they contain considerably less digestible protein and fat than the flesh foods, but furnish large proportions of digestible carbohydrates which are practically lacking in meat and meat products. The high fat content of most meats would, however, furnish more than enough energy to offset that of the carbohydrates in the cereals, so that as they appear on the table meats on an average supply, pound for pound, more digestible protein and have a higher energy value than the cereal breakfast foods, which are an excellent source of digestible carbohydrates and furnish at the same time considerable amounts of digestible protein; but they do not furnish the same amounts or proportions of nutrients as flesh foods.

DIGESTIBILITY.

A large number of experiments with healthy men, to learn how thoroughly cereal breakfast foods are digested, have been carried out at the Connecticut (Storrs), Maine, and Minnesota agricultural experiment stations, in the majority of which the cereals were eaten with cream and a little sugar and the digestibility of the cereal breakfast food alone was computed by the usual methods from the values

obtained from the ration as a whole. In other tests the cereals formed a fair proportion of a simple mixed diet, which is, of course, the way they are usually served. The "ready-to-eat" goods were served without further cooking. The others were thoroughly cooked.

Table 2 summarizes the results of the digestion experiments with cereal breakfast foods, similar data regarding some other food products being included for the purpose of comparison.

TABLE 2.—*Coefficients of digestibility of different classes of cereal foods and a few other foods.*

Kind of food.	Protein.	Fat.	Carbohydrates.	Energy.
CEREAL BREAKFAST FOODS.				
Oat products.....	77.9	a 90.0	97.0	87.8
Wheat products, malted, ready to eat.....	75.4	a 90.0	91.4	84.7
Wheat products, crumbed and malted, ready to eat.....	74.7	a 90.0	93.0	86.6
Wheat products uncooked, decorticated.....	80.9	a 90.0	95.6	89.3
Wheat products undecorticated.....	72.7	a 90.0	91.0	83.3
Wheat products, rolled, partially cooked.....	83.1	a 90.0	93.1	86.1
Rye products.....	b 77.8	a 90.0	b 93.8	b 86.4
Barley products.....	b 77.8	a 90.0	b 93.8	b 86.4
Buckwheat products.....	b 77.8	a 90.0	b 93.8	b 86.4
Corn products.....	73.9	a 90.	98.9	94.5
Rice products.....	83.0	a 90.0	98.0	90.0
Wild rice products.....	b 77.8	a 90.0	b 93.8	b 86.4
Kafir corn products.....	b 77.8	a 90.0	b 93.8	b 86.4
OTHER FOODS FOR COMPARISON.				
Bread, white.....	88.0	a 90.0	98.0	92.0
Bread, Graham.....	76.0	a 90.0	91.0	88.0
Bread, entire-wheat.....	82.0	a 90.0	94.0	87.0
Macaroni.....	86.8	a 90.0	97.4	92.1
Legumes.....	78.0	a 90.0	97.0	80.0
Potatoes.....	73.0	a 90.0	99.0	91.0
Beefsteak.....	98.0	98.0	.....	.....

^aEstimated value.

^bCalculated on the basis of available data.

The range in the digestibility of protein was greater than with carbohydrates or energy. As regards the protein of cereal breakfast foods, the highest coefficient of digestibility, 83.1 per cent, was noted with rolled-wheat products partially cooked—i. e., cooked at the factory—and the lowest coefficient, 72.7, with undecorticated wheat products. The cereal breakfast foods, in general, like entire-wheat and Graham bread, are somewhat less digestible than white bread.

In a series of digestion experiments made at the Maine Experiment Station rolled oats, rolled wheat, granulated corn meal, hominy, and some of the common commercial brands of specially prepared breakfast foods were studied. The ready-to-eat goods were used as manufactured, while the rolled wheat, oats, and other such brands were thoroughly cooked in a double boiler. In general, about 90 per cent or over of the organic matter was assimilated when the cereals were eaten in a mixed diet containing bread and meat and in a simple diet of cereal, cream, and sugar, and also when the results were computed for the cereal breakfast food alone. In the case of the mixed diet the highest coefficient of digestibility of protein, 93.2, was noticed

with rolled wheat, and the lowest, 88.9 per cent, with hominy. In the case of the simple diet, the range in the digestibility of protein was from 82.3 per cent with granulated corn meal to 91.6 per cent with rolled wheat. Considering the results as computed for the cereal breakfast foods alone, the lowest value, 57.7 per cent digestibility of protein, was noted with a specially prepared whole-wheat product, and the highest value, 85 per cent, with rolled oats. The availability of energy was high in all cases. It was not far from 90 to 93 per cent with the mixed diet. With the simple diet the range was somewhat greater, namely, from 91.1 per cent with a specially malted cereal to 96.4 per cent with hominy. With cereals alone the lowest value was 84.1 per cent available energy with a specially prepared whole-wheat cereal, and the highest value, 94.4 per cent, with hominy.

In these tests corn products with a mixed diet and with a simple diet made a favorable showing as regards both total organic matter and energy, but were inferior to the other goods in respect to the digestibility of protein. The conclusion was reached that if the cereal breakfast foods, especially those made from oats, corn, and wheat, are rated in proportion to the digestibility of their protein when used with a mixed diet, rolled wheat must be placed first and the corn products last. When the digestibility of the cereals alone was calculated, rolled wheat ranked first, not only in digestibility of the total organic matter, but also with respect to the protein. The rolled oats ranked next, and the corn preparations and a specially prepared whole-wheat product the lowest of all.

WHEAT PREPARATIONS WITH AND WITHOUT BRAN.

Much has been said recently about the comparative values of wheat preparations with and without bran. The bran of wheat consists of three layers, all of which contain larger proportions of crude fiber than the interior of the grain. The two outer layers also contain more of certain desirable mineral matters, notably phosphorus compounds, lime, and iron, than the other parts of the grain, while the innermost layer contains a special kind of protein, also valuable. In Graham flour and perhaps a few of the whole-wheat breakfast foods all the bran is left in. In the so-called "whole" or "entire" wheat flours and most wheat breakfast foods, the attempt is made to remove the two outer coats and all three seed coats in making the white or patent-process flour and some of the special breakfast-food preparations. The question is whether or not the mineral matters and protein gained from the bran compensate for the increase in cellulose. In a large number of experiments with bread made from the different kinds of flour,^a it was found that however superior Graham and entire-wheat

^a U. S. Dept. Agr., Office of Experiment Stations Buls. 85, 101, 126, 143.

flour were in composition, the bread made from them was so much less thoroughly digested that they supplied the body with less available nutrients than similar bread made from white flour. Experiments which have been made with cereal breakfast foods also show that the presence of bran slightly lessens the amount of nutrients digested.

For persons troubled with constipation food products containing the bran are doubtless often valuable, as the coarse particles tend to increase the peristaltic action of the intestines. Whether or not they should be given to invalids is a question for physicians, who are acquainted with the special cases, to decide. The difference between them and the bran-free foods is, however, so slight that the ordinary healthy person can safely consult his taste, convenience, and economy in choosing between them, as all are wholesome and quite generally palatable. It should be remembered also that the use of a number of different kinds of foods of a similar character is one way of giving variety to the diet, and variety is generally admitted to be desirable.

"PREDIGESTED" AND "MALTED" BREAKFAST FOODS.

The idea of having part of the process of digestion performed outside of the body is not a new one, nor is it confined to human food. About thirty years ago there was a furor over malted fodder for cattle, which it was claimed would greatly increase the strength and flesh of the animals by sparing them part of the work of digestion. It was soon found, however, that the cattle did fully as well when left to perform their own work of digestion in the way that nature intended.

Physicians have used predigested foods of different sorts for their patients for many years. Since the diastase of malt imitates the work of the diastase of saliva and pancreas so well, it is the common means of predigesting carbohydrates, when that is necessary, just as the preparations of pepsin and pancreatic juice are used for the predigestion of protein. Ordinarily predigested foods are intended for invalids under special conditions, and for them only on the doctor's orders. The modern American breakfast foods, however, which claim to be predigested are recommended by the manufacturers for general use.

The diastase of malt is, as has been said, supposed to change the insoluble starch in these cereal foods into more soluble forms. If sufficient malt were used under the right conditions, a considerable portion of the starch would undoubtedly be thus transformed. But this does not appear to be the case in the majority of the preparations which claim to be predigested. Among a number of malted breakfast cereals analyzed at the Iowa Experiment Station^a the largest amount

^a Iowa Sta. Bul. 74, p. 133.

of soluble carbohydrates found was 13.23 per cent of the total carbohydrates, the next largest 10.91 per cent, and the lowest 0.35 per cent, while the average was in the neighborhood of 5 per cent. Judging from other analyses,^a dextrin forms the largest part of the soluble carbohydrates in these preparations. In some cases the soluble carbohydrates may have been formed by the action of malt, but there is reason to believe that in certain cases soluble carbohydrates like glucose were simply added during the process of manufacture. Moreover, most of these malted goods seem to have been parched or cooked in part by dry heat, and some dextrin or other soluble carbohydrate is commonly produced from starch by dry heat without the aid of diastase. Hence it appears that in most of the malted cereals very little of the starch is converted into any soluble form other than dextrin, and that the dry heat of cooking produced at least a part of that change. Certainly the claims made for some brands that the carbohydrates are completely or largely predigested are quite unwarranted. Furthermore, it must be remembered that if the cereal foods are thoroughly cooked at home before serving, the proportion of soluble or at least gelatinized carbohydrates formed will be fairly high, certainly as high or higher than in the predigested foods designed to be eaten raw. Malt has a characteristic taste which is relished by many, and on this account the malted cereals are often liked. Their use helps to add variety to the diet, which, as noted above, is an advantage.

It is interesting to note that a product in appearance and taste very closely resembling some of the granular specially prepared breakfast foods may be made at home by dipping small pieces of Graham bread in a dilute mixture of glucose and malt, drying in an oven, and crushing. (See also p. 31.)

It seems to be the case, then, that these special cereal foods do not merit the name "predigested," and this may be an advantage rather than the reverse. It is questionable whether it would be of advantage to a healthy person to have his food artificially digested. The body under normal conditions is well adapted to utilize such foods as the ordinary mixed diet provides, among them the carbohydrates from the cereals. Moreover, it is generally believed that for the digestive organs, as for all others of the body, the amount of exercise they are normally fitted to perform is an advantage rather than the reverse. It has been said that "a well man has no more need of predigested food than a sound man has of crutches." If the digestive organs are out of order it may be well to save them work, but troubles of digestion are often very complicated affairs and the average person rarely has the knowledge needed to prescribe for himself. In general, those who are well should do their own work of digestion and those who are ill should consult a competent physician.

^a Michigan Sta. Bul. 211, p. 19.

While breakfast foods of this class are usually not predigested, as they claim to be, they are, on the other hand, quite free from harmful ingredients and have much the same nutritive value as other preparations of similar grains and have a flavor which many like. They are on an average higher priced than the others, but aside from this consideration of economy there is no reason why those who like them should not use them as they do other ready-to-eat cereals.

COOKING.

For the average person the proper cooking of cereals is quite as important as the proportions of different nutrients which they contain. Variations in the composition of similar brands are, as has been shown, for the most part comparatively unimportant, but it seems fair to assume that indifferent cooking affects more or less the ease of digestion and the amount of nutrients which the body can extract from a dish of cereal and at the same time detracts from the pleasure of eating. The chief purposes of cooking are (1) to sterilize the material, so that any undesirable bacteria or parasites or their eggs if accidentally present may be rendered harmless; (2) to improve flavor and appearance; and (3) to produce such changes in structure that the digestive juices may act more readily upon the nutrients present. Heat, especially that employed in the process of manufacture, improves the keeping quality, though this is not so important in the case of cereal foods as of some other food materials, because if the grains are well cleaned and are marketed and stored under proper conditions they should be free from dirt, mold spores, insects, etc., and, furthermore, they are so dry that they do not furnish a good medium for the growth of molds, bacteria, and other low forms of vegetable life. It is interesting to note that parching as a means of improving keeping quality was practiced long before the reasons for the process were known. Thus, the American Indians often parched their corn before storing it, and indeed this practice seems to have been very generally followed since early times in most countries when it was desired to store grains or seeds or to protect them during transportation.

The second purpose of cooking, to improve flavor and appearance, has a value beyond a mere catering to the eye and to the palate, since there may be a direct gain in digestibility. Appetizing foods in some way stimulate the flow of the digestive juices, while those that are eaten without relish seem to retard it.

The third purpose of cooking, to convert the nutrients into more digestible forms, is especially important in vegetable foods which, like the cereals, contain a large proportion of crude fiber. As has been stated, the nutrients of the grain are found inside the starch-bearing and other cells, and the walls of these cells are made of crude fiber, on

which the digestive juices have little effect. Unless the cell walls are broken down, the nutrients can not come under the influence of the digestive juices until the digestive organs have expended material and energy in trying to get at them. Crushing the grain in mills and making it still finer by thorough mastication breaks many of the cell walls, and the action of the saliva and other digestive juices also disintegrates them more or less, but the heat of cooking accomplishes the object much more thoroughly. The invisible moisture in the cells expands under the action of heat, and the cell walls burst; and the water added in cooking also plays an important part in softening and rupturing them. Then, too, the cellulose itself may be changed by heat to more soluble forms. Heat also makes the starch in the cells at least partially soluble, especially when water is present. The solubility of the protein is probably as a rule somewhat lessened by cooking, especially at higher temperatures. Long, slow cooking is therefore better, as it breaks down the crude fiber and changes the starch to soluble forms without materially decreasing the solubility of the protein.

Investigators differ as to the amount of soluble carbohydrates produced by long-continued cooking. Gudeman^a reports 38 per cent soluble carbohydrates in cooked as compared with 5 per cent in raw breakfast cereals.

In experiments made with rolled oats at the Minnesota Experiment Station^b it appeared that cooking (four hours) did not make the starch much more soluble. However, it so changed the physical structure of the grains that a given amount of digestive ferment could render much more of it soluble in a given time than when it was cooked for only half an hour.

On the basis of the results obtained, the difficulty commonly experienced in digesting imperfectly cooked oatmeal was attributed in a discussion of these experiments to the large amounts of glutinous material which surround the starch grains and prevent their disintegration. When thoroughly cooked the protecting action of the mucilaginous proteid material is overcome, and the compound starch granules are sufficiently disintegrated to allow the digestive juices to act. In other words, the increased digestibility of the thoroughly cooked cereal is supposed to be largely due to a physical change in the carbohydrates, which renders them more susceptible to the action of digestive juices. The rupturing of hard cell walls by the heat of cooking is also of importance, as was pointed out above.

Cereals differ considerably in the amount of cooking required to make them as digestible as possible, but not enough is definitely known on the subject to say exactly how long each kind should be cooked.

^a Jour. Amer. Chem. Soc., 26 (1904), p. 321.

^b Minnesota Sta. Bul. 74, p. 153.

In general, it is true that the more abundant and coarse the crude fiber the longer should be the cooking period. For this reason whole grains require longer cooking than partially crushed ones, and those containing the skin of the seed more than those from which it has been removed. For instance, whole corn kernels require longer cooking than fine hominy, and whole wheat preparations more than flour gruel. Rice, which is remarkably free from crude fiber, can be thoroughly cooked in a comparatively short time.

In the case of the partially cooked cereals it is difficult to know how much of the necessary cooking has been done at the factory. It is safe to assume that they still require at least all the cooking suggested in the directions usually accompanying the package and probably would not be harmed by considerably more. Physicians sometimes complain that these preparations are indigestible and prefer old-fashioned home-cooked grains. Yet it is hard to see why the partially cooked cereals, if they are properly recooked before serving, should not be just as digestible as those cooked entirely at home, and they certainly permit some economy in fuel and time. With all cereals it should be remembered that overcooking is unusual and harmless, while undercooking is common and undesirable.

Recent experiments on the digestibility of the protein of oatmeal indicate that this nutrient is more thoroughly digested when the meal is well cooked than when only slightly cooked, and also when the oats are rolled or malted than when simply crushed and boiled, probably because the increased heat or pressure or the action of the malt breaks down more of the cell walls. In other experiments, where the digestion of the protein of the wheat was artificially imitated by the use of pepsin, raw separated gluten was found more digestible than cooked, and gluten gruel more digestible than gluten wafers. Such experiments, however, represent only a part of natural digestion, and their results would be of importance mainly in the case of invalids, as the whole process of digestion of normal persons would probably insure reasonably complete digestion.

ABSORPTION OF WATER—SOLUBILITY OF CEREALS—GRUELS.

When cereals are cooked in water two kinds of changes occur besides those already referred to—i. e., part of the water is absorbed into the grain and part of the solid matter passes into the water. Some cereals absorb much more water than others before they are sufficiently cooked to be at their best. This probably depends largely on the amount of time required for cooking. Raw oatmeal contains only 7 per cent of water (see Table 1), but when cooked 84 per cent, according to recent analyses. On an average the amount of water in hominy increases from 11 to 79 per cent in cooking and that in rice from 12 to 72 per

cent. If we consider cereals in the form in which they come on the table, we certainly get a larger proportion of nutrients from those that absorb the least water. Because it is drier a saucer of cooked rice actually has a higher food value than a like quantity of cooked oatmeal. From this it might be argued that the dry ready-to-eat cereals are preferable to those cooked at home, but this is not necessarily the case. Many persons, if they do not actually soften the dry and ready-to-eat cereal foods with hot water before serving, add considerable milk or cream to them and so make a saucerful about equal in moisture content and total food value to a like dish of any other cereal.

There are probably differences in the amount of solid matter removed by water in cooking different cereals, but little is definitely known on this subject. If rice is boiled in an abundance of water, the latter becomes thickened and forms a sort of starch paste, showing that some material may be lost in boiling rice if the water is thrown away. This is one of the reasons why many persons prefer steaming to boiling as a method of cooking this food. In most cases the losses in cooking cereal foods are probably negligible. When milk, sugar, salt, etc., are added to cereal foods in cooking or serving, the total food value of the dish is, of course, greater than that of the cereal alone.

Some instances of the practical application of the fact that part of the nutrients of cereals are soluble in water may not be without interest. Barley water, an old-fashioned beverage much thought of in the sick room, is made by boiling barley in water and straining the clear liquid from the undissolved barley. Oatmeal water is a similar preparation often given to sick persons. It is also frequently used as a beverage by athletes and by workmen engaged in severe labor, as it is believed to quench thirst more satisfactorily than water. This beverage is prepared by mixing the raw oatmeal with water, stirring it thoroughly and allowing the coarser particles to settle. Some material is dissolved and some fine particles undoubtedly remain suspended in the liquid, which takes on a somewhat milky appearance.

Gruels—that is, thin porridges made from oatmeal, rice, corn meal, etc.—are usually cooked for a long time and owe their characteristic consistency largely to starch in the form of paste, i. e., hydrated and gelatinized starch, though undoubtedly some insoluble material is retained in suspension. By passing the material through a sieve the coarser undissolved portions of the grain are removed and a smooth, more or less thick mass remains, which contains a considerable amount of nutritive material. When well made and seasoned such porridges or gruels are very palatable. At the same time the dish is so dilute that it does not overtax weakened digestive organs.

Of course, the amount of nutritive material in gruel depends largely on the proportions of water and cereal used. In recent analyses^a it was found that strained gruels made with a quart of water and an ounce of barley, rolled oats, or wheat flour contained on an average about 2 per cent of solid material, while 8 ounces of cereal with the same quantity of water gave 18 to 20 per cent of solids. Dextrinized oats and wheat yielded a richer gruel than the ordinary grains.

In the section on cereal coffee (p. 33) mention is made of a class of cereal products which owe their nutritive value to the soluble constituents which they contain.

RAW CEREAL FOODS.

Doubtless the number of persons who would care for raw cereal foods in any considerable amount is limited, but those who wish them can readily purchase cleaned raw grains which, though hard, can be masticated without any special difficulty. Raw cereal breakfast foods and other products made from the uncooked grains are also on the market, in which the hard kernel has undergone some special treatment which makes it a more convenient article of diet than the raw whole grain. It is sometimes claimed that raw foods possess special virtues because some vital principle or life force in them has not been destroyed by cooking. Such views are not supported by experimental evidence nor does physiological chemistry offer data which would warrant the belief that they are true. On the other hand, there is no reason to suppose that uncooked cereal foods are unwholesome if clean and free from bacteria, and they are commonly said to be especially useful in counteracting constipation on account of the large amount of indigestible crude fiber which they supply.

ADULTERATION OF CEREAL BREAKFAST FOODS.

The cereal breakfast foods as a class, it seems fair to say, are ordinarily free from adulteration. Various experiment station chemists and public analysts in States having pure-food laws have examined the brands on the market, as indeed they examine all classes of food at frequent intervals, and found that as a general rule they were made from good sound grain without admixture of harmful substances. Some may be made from coarse milling products, such as wheat middlings, and some doubtless contain molasses, glucose, or other similar materials which do not appear in the manufacturer's description, but which are not injurious.

Occasionally the percentage of ash or mineral matter in breakfast foods is abnormally high, but this is apparently due to common salt added to give flavor and not as an adulterant. In general, it may be

^a Med. Rec., 67 (1905), pp. 246, 275.

said that there is every reason to suppose that the manufacturers endeavor to use wholesome materials and that if an impurity is occasionally found in their goods it is accidental rather than intentional. Furthermore, cereal breakfast foods, as previously noted, are generally made from well-cleaned grain and are marketed in a cleanly way. In the case of the package goods the form of marketing affords special protection while the goods are in the dealer's hands and also in the household, where they are very commonly kept in the original cardboard box or package.

COST OF CEREAL BREAKFAST FOODS.

Just as the nutritive value of any food depends not on the total composition, but on the digestible nutrients, so its real cheapness or dearness depends not merely on the price paid in the market, or even that price plus the cost of cooking, but on the cost of the digestible nutrients it contains; or, to put it in another way, on the amount of digestible nutrients furnished for a given sum. Shoulder of beef at 12 cents a pound seems like a cheap food, and so it is compared with the the more expensive cuts of meat; but it contains so much water and refuse (bones, gristle, etc.) that 10 cents spent for it will buy only about one-fifth as much actual nutrients as the same sum spent for bread.

The cereal grains are comparatively free from water and refuse, and so there is less range between their price per pound and the cost of their nutrients than is the case in other foods. The different brands of breakfast foods, however, vary greatly in price, and although, to a certain extent, these variations may be due to differences in the cost of preparation, price does not indicate very closely the nutritive value of the goods. Table 3 shows the real cost of the digestible nutrients in the different breakfast preparations as they compare with one another and with the other classes of food bought at ordinary market prices.

TABLE 3.—Comparative cost of digestible nutrients and available energy in different cereal breakfast foods.

Kind of food.	Price per pound.	Cost of one pound of pro- tein.	Cost of 1,000 calories of en- ergy.	Amount for 10 cents.					
				Total weight of ma- terial.	Pro- tein.	Fat.	Carbo- hy- drates.	En- ergy.	
Oat preparations:									
Oatmeal, raw	3	.24	1.7	3.33	.42	.22	2.18	5.884	
Do	4	.32	2.3	2.50	.31	.16	1.64	4.418	
Rolled oats, steam cooked	6	.48	3.4	1.67	.21	.11	1.08	2.938	
Wheat preparations:									
Flour, Graham	4	.40	2.6	2.50	.25	.01	1.61	3.790	
Flour, entire-wheat	5	.46	3.1	2.00	.22	.03	1.36	3.188	
Flour, patent	3.5	.35	2.1	2.86	.29	.03	2.10	4.700	
Farina	10	1.12	6.2	1.00	.09	.01	.73	1.609	
Flaked	15	1.69	9.3	.67	.06	.01	.46	1.005	
Shredded	12.5	1.62	8.2	.80	.06	.01	.57	1.217	
Parched and ground	7.5	.88	4.9	1.33	.11	.02	.94	2.050	
Malted, cooked, and crushed	18	1.48	8.5	.77	.07	.01	.53	1.175	
Flaked and malted	11	1.21	7.2	.91	.08	.01	.62	1.389	

TABLE 3.—Comparative cost of digestible nutrients and available energy in different cereal breakfast foods—Continued.

Kind of food.	Price per pound.	Cost of one pound of protein.	Cost of 1,000 calories of energy.	Amount for 10 cents.				
				Total weight of material.	Protein.	Fat.	Carbohydrates.	Energy.
Barley preparations:								
Pearled barley	7	1.06	4.6	1.43	0.09	0.01	1.04	2,165
Flaked, steam cooked	15	1.83	9.6	.67	.05	.....	.50	1,051
Corn preparations:								
Corn meal, granular	3	.44	1.8	3.33	.23	.06	2.48	5,534
Hominy	4	.62	2.4	2.50	.16	.01	1.97	4,178
Samp	5	.78	3.0	2.00	.13	.01	1.57	3,342
Flaked and parched	13	1.73	7.5	.77	.06	.01	.60	1,335
Rice preparations:								
Rice, polished	8	1.48	4.7	2.25	.07	.....	.94	1,855
Flaked, steam cooked	15	2.31	9.8	.67	.04	.....	.51	1,026
Miscellaneous foods for comparison:								
Bread, white	6	.74	5.0	1.67	.14	.02	.87	2,009
Do	5	.62	4.2	2.00	.16	.02	1.04	2,406
Crackers	10	1.10	5.3	1.00	.09	.08	.71	1,905
Macaroni	12.5	1.08	7.5	.80	.09	.01	.58	1,328
Beans, dried	5	.28	3.5	2.00	.35	.03	1.16	2,868
Peas, dried	5	.26	3.4	2.00	.38	.02	1.20	2,974
Milk	3	.94	9.7	3.33	.11	.13	.17	1,030
Do	3.5	1.09	11.3	2.86	.09	.11	.14	885
Sugar	5	.....	2.8	2.00	.....	.....	2.00	3,515
Do	6	.....	3.4	1.67	.....	.....	1.67	2,940

The first column of figures gives the price paid for a pound of the material in the open market, the second and third the sum necessary to buy 1 pound of digestible protein and 1,000 calories of available energy, and the last five show how much of total material, digestible nutrients, and how many calories of available energy 10 cents will purchase when spent for the different food materials.

If the cereals are compared on the basis of the price paid per pound, the corn and oat preparations appear to cost the least; then wheat, barley, and rice, in the order named. In 50 cereal breakfast foods studied at the Maine Experiment Station^a the average price of the corn preparations was 5.7 cents per pound; of the oat preparations, 6 cents; and of the wheat preparations (exclusive of four excessively high-priced goods), 10.6 cents per pound. Ready-to-eat, partially cooked, and raw preparations were grouped together in this comparison, but prices of these three classes of goods vary so much that it would perhaps be fairer to consider each class by itself. The minimum selling price of the ready-to-eat preparations given in Table 3 is 11 cents per pound, the maximum 15 cents per pound, and the average 12 cents per pound. The partially cooked brands also cost somewhat more than the raw ones, but these differences are not so noticeable, their prices as quoted in Table 3 ranging from 3.1 to 8.6 cents per pound, with an average of 6.8 cents. So far as the available data show, the raw cereal breakfast foods sell for about 4 cents per pound in bulk. The average price of the wheat preparations is much higher than that of similar preparations of oats or corn.

^a Maine Sta. Bul. 74, p. 151.

When we consider the amount of nutrients furnished by the different cereals the order changes somewhat. Taking these facts into consideration, it can perhaps be said that the real cheapness of the cereal breakfast foods runs in the following order: Oats, corn, wheat, barley, and rice, but it must not be forgotten that the differences are comparatively slight and the order would be changed by a little variation in price or quality. The ready-to-eat preparations of any of the grains have about the same proportion of digestible nutrients as the grains from which they are made, but they are in general more expensive. Judged on the basis of food value, the higher price is paid mainly for convenience, novelty, and the advantage, if any, due to special flavor.

The cost of labor and fuel in preparing food is always an important consideration in determining its real economy. In large establishments and in households where a fire is kept in the range all day for other purposes, it takes no extra fuel and very little labor to cook the cheap raw cereals. But if the cooking is done on a gas stove, and if time and labor are limited, it may be better economy to use the partially cooked or the ready-to-eat brands. Certainly, thoroughly cooked ready-to-eat cereals are more truly economical than others eaten badly cooked. Again, if storage space is valuable the small packages in which the proprietary goods are sold have an advantage, and such goods are, under some conditions, fresher and cleaner.

The ready-to-eat cereals undoubtedly give a pleasant variety and are very convenient. If rigid economy is necessary, the cost of most sorts would seem to make their use almost out of the question when the amount of actual nutritive material supplied for a given sum is considered. Each housekeeper must decide for herself how much she can afford to pay for any special convenience and for variety.

The breakfast foods which are not cooked at the factory and flours and meals made from the same grains do not vary much in price or in composition, and whatever differences in value there may be between them depend mainly on the amount of cooking each requires. The partially cooked grains in general are cheaper per pound than macaroni and furnish the food ingredients at less cost. They probably require about the same time to cook them properly. If milk and sugar are eaten with the breakfast foods, or if cheese or other materials are added to the macaroni, these will increase the cost, but also the nutritive value of the dish. At the usual prices the nutrients in ready-to-eat cereals are considerably dearer than those furnished by bread and crackers.

As regards the other classes of foods included in Table 3, it will be seen that the dried legumes are cheaper sources of protein than any of the cereals, but have a slightly lower fuel value than oatmeal and corn

meal at corresponding prices. When cooked they are more economical than the higher-priced breakfast foods, notwithstanding the fact that they are somewhat less thoroughly digested. However, it would of course not accord with ordinary food habits to substitute legumes for cereals, and this is not intended by the comparison. All animal foods, especially meats, are more expensive even as sources of protein than cereals. The skillful housewife who wishes to provide an economical and palatable menu should bear such facts in mind in planning her meals.

To sum up the foregoing statements, cereals supply actual digestible nutrients to the body more cheaply than any other class of foods except the dried legumes. The less expensive kinds of breakfast foods are as economical as flour or the other forms of cereals with which they may justly be compared. The comparatively expensive ready-to-eat brands do not yield any extra nutritive value for their higher cost, and, so far as can be seen from the available evidence, their only advantage lies in their convenience and the pleasant variety they offer.

BREAKFAST CEREALS PREPARED AT HOME.

In early times there were many ways of preparing grains and meal, such as frumenty and the good King Arthur's famous "bag pudding." The partially cooked and ready-to-eat cereals have become so popular of late years that the old-fashioned ways of cooking the grains are less common than formerly. The ingenious housekeeper can, however, secure considerable variety in her breakfast cereals by the use of the simple meals or grains.

One of the dishes which the early New England settlers doubtless copied from their Indian neighbors is the homely "corn-meal mush," or hasty pudding, which is easily made by boiling ordinary corn meal in milk or water. If properly cooked, it is a very nutritious and economical dish and has the further advantage, dear to the thrifty housewife, that the "left over" portion will be relished if cut in slices and fried. Another popular way of using certain varieties of corn is as popped corn. This can hardly be termed a breakfast food, but it is not infrequently eaten with milk, like other cereal preparations, and for many reasons may be classed with the materials here discussed. As everyone knows, pop corn kernels, when exposed to a great heat, like that from a good bed of coals, will burst open, the white endosperm "popping" through the torn outer husk. This bursting was formerly supposed to be due to the expansion of the fat in the grain under the influence of the heat. It is now known to be due to the sudden expansion of moisture into steam in the starch cells, which burst like small bombs. Popping causes a noticeable change in the proportion of the nutrients of corn, but this is mainly due to the loss of water. What

gives popped corn its peculiar flavor is not definitely known, though it is probably due chiefly to a slight caramelization of the carbohydrates present. Rice may be popped like corn, although of course the meshes of the "popper" must be finer.

Hominy in the old days was made at home by pounding the corn, and lye hominy or hulled corn was also a homemade product. These products can now be purchased so readily that probably not many care to take the trouble to prepare them in the household.

Another very economical and appetizing dish is that known, in New England at least, as rusks, made by drying and lightly browning stale bread or cake in the oven and then crushing. Rusks are eaten with milk or cream, like any of the dry breakfast foods. In a recent bulletin of the South Dakota Experiment Station^a such a product is described under the name of dextrinized crumbs.

It has already been stated that drying whole-wheat or Graham bread with a little glucose and malt extract gives a product very like some of the ready-to-eat brands of breakfast foods in appearance and flavor, but it would doubtless not be worth while to prepare such foods in the household. Any stale bread may, however, be dipped in a little molasses and water, dried from twelve to twenty-four hours in the warming oven of an ordinary range, then crushed and served like the granular brands of breakfast foods. Many tests have been carried on with such homemade breakfast foods, and they seem to be quite as appetizing as the preparations which they resemble and which sell for 12.5 or 15 cents a pound.

If the labor of cooking must be taken into account, and strict economy is needful, crackers in milk may well be substituted for the ready-cooked breakfast cereals. As has been seen, crackers are similar to the regular breakfast foods in composition, and at average prices furnish more nourishment for the same amount of money. Nor should it be forgotten that as a rational, palatable, and economical dish bread and milk ranks very high.

THE PLACE OF CEREAL BREAKFAST FOODS IN THE DIET.

It has been estimated that a man at moderate work requires about a fifth of a pound of protein and about 3,000 calories of energy per day. As a general rule the protein is in considerable measure supplied by meat, fish, milk, and other animal foods, which also supply the bulk of the fats. The carbohydrates, which are lacking in animal foods, are abundantly supplied by the vegetable foods, which also provide some protein and a little fat. Fresh fruits and vegetables supply acids and other bodies which are believed to have a distinct value as stimulants to the appetite and in other ways. The mineral matters

^aSouth Dakota Sta. Bul. 77, p. 36.

needed in a well-balanced diet occur in small but sufficient quantities in almost all classes of food materials. In a mixed diet the energy-producing carbohydrates are more important ingredients of the vegetable foods than protein, which will be supplied by animal foods. Of course, if for any reason the animal foods are omitted from the diet, the importance of protein and fats in the vegetable foods increases greatly. In such cases the legumes and cereals, which contain more protein than the vegetables and fruits, take a very important position in the menu.

The most important use of cereals is undoubtedly as breadstuffs. Bread has thoroughly established its place as the most palatable, nutritious, and convenient cereal preparation for general use. Crackers or biscuit and the various kinds of cake, pastry, etc., are in a way varieties of bread or substitutes for it and are recognized as staple foods. What place, then, is left for the so-called breakfast foods?

At dinner, aside from bread and sweets, carbohydrates are supplied in the vegetables served with the meat. In the morning and sometimes also at luncheon or supper these do not seem so attractive or convenient and in their place we use some preparation of cereals. There are reasons for believing that there is a growing tendency in this country to use less meat at all meals, perhaps, excepting dinner. This, of course, increases the importance of cereal foods as part of the diet.

Some of the prepared cereal foods are pressed into cakes or in some other way manufactured into such forms that they may be eaten to a greater or less extent like bread or crackers as an accompaniment to various dishes. Such preparations are undoubtedly wholesome and nutritious, but except for their flavor and texture, which may appeal to many, they do not surpass the ordinary breads, which experiments have shown have as great or greater nutritive value and usually cost less. Cereal breakfast foods of different kinds are used to a greater or less extent in the preparation of made dishes. Thus, a spiced steamed pudding may be made from oatmeal, and very palatable little cakes can be made from some of the dry flaked cereals. Fried hominy and fried corn-meal mush are standard foods sometimes served with fried chicken and some other dishes, and boiled rice is a common substitute for potatoes or other starchy foods. The manufacturers of certain classes of goods have taken great pains to devise recipes for their use in making desserts and as ingredients of other dishes. The amount of these cereal foods used in this and other similar ways is probably large, but the bulk of the total output of the mills and manufactories is used to provide a special breakfast dish.

In the diet of young children cereal foods are of much value. The cereal breakfast foods, when they agree with the children, are whole-

some and reasonably economical articles. When eaten, as is usually the case, with milk or cream they are an important addition to the diet. The ill effects sometimes noted may usually be avoided if excessive amounts of sugar are not added. Dates or figs, which are sometimes cooked with cereals, not only are palatable and wholesome, but also offer an easy way of varying the cereal dish.

Cereal breakfast foods of different sorts are also valuable foods for the aged, as when properly cooked they are soft and easily taken care of in the digestive tract. They are often preferred to more hearty foods, and their use is certainly rational. In institution dietetics, especially when a considerable number of the inmates are children or aged persons, some breakfast cereal should find a place in the menu, and is not inconsistent with economy.

In invalid dietetics cereal foods are, of course, almost indispensable, and the standard flours and meals and the more modern prepared breakfast and special cereal foods all find their place, either when cooked in ordinary ways or for the preparation of gruels or other special dishes.

CEREAL PRODUCTS AS COFFEE SUBSTITUTES.

Cereal products as coffee substitutes are so closely related to cereal breakfast foods that it seems best to say something of them here. Several experiment stations have recently made analyses of them which have been briefly summarized in a bulletin of this Department.^a A few contain a little true coffee, but for the most part they appear to be made of parched grains of barley, wheat, etc., or of grain mixed with pea hulls, corncobs, or wheat middlings. It is said that barley or wheat parched with a little molasses in an ordinary oven makes something indistinguishable in flavor from some of the cereal coffees on the market. The manufacturers claim that they make a harmless, unstimulating substitute for coffee, hardly to be distinguished from it in flavor and yielding much greater nourishment at lower cost. If no coffee is used in their preparation, the claim that they are not stimulating is undoubtedly true. Few coffee lovers will admit, however, that cereal substitutes equal or even resemble true coffee in flavor. As for the nutritive value, parching the cereal grains undoubtedly renders some of the carbohydrates soluble, and part of this soluble matter passes into the decoction, but only a small part, as the following data for commercial cereal coffee, prepared according to the manufacturer's directions included in Table 4, show. The table also contains, for purposes of comparison, data regarding the composition of homemade cereal coffee (parched corn), tea and coffee infusions, etc.

^a U. S. Dept. Agr., Farmers' Bul. 122, p. 22.

TABLE 4.—*Composition of cereal-coffee infusion and other beverages.*

Kind of beverage.	Water.	Protein.	Fat.	Carbo-hydrates.	Fuel value per pound.
	Per cent.	Per cent.	Per cent.	Per cent.	Calories.
Commercial cereal coffee (0.5 ounce to 1 pint water).....	98.2	0.2	.....	1.4	30
Parched-corn coffee (1.6 ounces to 1 pint water).....	99.5	a.2	.....	.5	13
Oatmeal water (1 ounce to 1 pint water).....	99.7	a.3	.....	.3	11
Coffee (1 ounce to 1 pint water).....	98.9	.2	.....	.7	16
Tea (0.5 ounce to 1 pint water).....	99.5	.2	.....	.6	15
Cocoa (0.5 ounce to 1 pint milk).....	84.5	3.8	4.7	6.0	365
Cocoa (0.5 ounce to 1 pint water).....	97.1	.6	.9	1.1	65
Skimmed milk	90.5	3.4	.3	5.1	170

^a Assumed.

The bulk of the infusion of cereal coffee, tea, and coffee is seen to be water, and so the nutritive value must be correspondingly low. Skimmed milk is about twenty times as nutritious. Cereal-coffee infusion, like real coffee, owes its flavor and color largely to the caramelized carbohydrates formed by roasting the original material. However, there are also special volatile bodies in true coffee, which give it the characteristic "coffee" flavor. The cereal substitutes are undoubtedly cheaper than the real article, costing as they do from 10 to 20 cents per pound less than the coffee berry, though much more expensive than home-parched rye or corn. For those who, for any reason, can not drink true coffee the cereal coffees furnish a harmless substitute, but the nutritive value of the infusion, like that of coffee or tea, is hardly worth considering in the ordinary diet.

If strict economy is necessary, it would perhaps be wiser and probably just as pleasant to use the old-fashioned "crust coffee," made by steeping the toasted or browned broken crusts of white, brown, or preferably "rye and Indian" bread in hot water, and then straining until comparatively clear. Parched corn, rye, or sweet potatoes, and other old-fashioned coffee substitutes, may also be used.

SUMMARY.

There is such a bewildering variety of cereal breakfast foods on the market, with such differences in appearance, taste, and claims to nutritive value, that it is hard to make an intelligent choice between them. True economy here, as with other kinds of food, depends upon the amount of digestible nutrients which can be obtained for a given sum of money.

Of the five cereals most commonly used for breakfast foods, oats contain perhaps the largest quantities of the important nutrients, with a fairly low proportion of crude fiber. Wheat ranks very close to oats in all respects, however, and even when prepared with the bran is freer from crude fiber. Many persons consider that the bran contains so much protein and desirable mineral matters that it should be retained in spite of the crude fiber which it contains. Digestion experiments

indicate, however, that the crude fiber makes the whole material so much less digestible that more protein is actually available to the body when the bran is excluded. Moreover, the ordinary mixed diet probably furnishes all the mineral matters which the healthy body needs, so bran is not needed for this purpose. The bran-containing preparations should be avoided by persons of weak digestion, but are often useful in cases of constipation. Such differences are, however, too small to be of importance to normal, healthy persons, and all the ordinary varieties of breakfast cereals are wholesome. Individual taste must determine which are most palatable. Appearance, palatability, and relative cost will always and rightly be important features in the selection of all these cereal breakfast foods. Corn and its preparations are rich in carbohydrates and fat, but are slightly less digestible than the other cereals. Rice is poor in protein, but remarkably free from crude fiber, and consequently furnishes a large proportion of digestible carbohydrates. Barley contains a fair proportion of nutrients and is moderately digestible. All these differences in composition and digestibility are comparatively slight and may be disregarded by healthy persons living on the ordinary mixed diet.

Thoroughness of cooking is a factor which has a bearing upon digestibility. It not only makes the cereals more palatable, but also breaks down the walls of indigestible cellulose which surround the starch grains and other nutrients and produces other changes so that the digestive juices can work on the nutritive ingredients more effectively. Poorly cooked cereals are less palatable than the same dishes well cooked and may cause indigestion and be really harmful. When the partially cooked preparations are used care should be taken to insure sufficient recooking before serving. The majority of the ready-to-eat brands are apparently thoroughly cooked.

In choosing between the various breakfast foods it must be remembered that a novel appearance and quasi-scientific name do not necessarily represent any unusual food value. Unless something is added during the process of manufacture, all brands must have just about the same composition as the cereals from which they are made, as manipulation can not increase the amount of food material in a cereal product, though it may materially modify its appearance and flavor. As far as the claims to predigestion are concerned, it is safest to assume that in at least the majority of cases the goods do not contain a much larger proportion of soluble—i. e., partially digested—starch than any thoroughly cooked cereal. Fortunately, the matter is of little importance to healthy persons, since they are probably better off for doing their own normal work of digestion. If any one is so ill as to need predigested food, he should depend upon the professional advice of a competent physician in selecting it. The predigested and malted cereals should be judged by the same standards as the others.

It should not be forgotten that breakfast cereals of all sorts are usually free from harmful adulterants and that, especially in the case of package goods, they reach the consumer in a clean, fresh condition.

The investigations made at the agricultural experiment stations have thus far failed to discover any uniform relation between price and nutritive value. The retail prices of breakfast cereals run all the way from 3 cents a pound for some of the plain meals sold in bulk to 15 cents or more for some of the ready-to-eat brands. The proportion of nutrients supplied, pound for pound, does not differ greatly. The partially cooked brands, usually medium priced, are certainly easier to prepare than the raw grains and may be more truly economical in households where time, labor, and fuel are scarce. In general, the ready-to-eat brands are higher in price than the partially cooked goods, though they have practically the same nutritive value, pound for pound, as other classes of cereal breakfast foods. The extent to which they should be used for their special flavor and the variety they give to the diet must be decided according to individual circumstances. It is only fair to add, however, that, whatever the relative food values of malted and unmalted foods, the cost of the former to the manufacturer is greater, and the increased price is to this extent justified.

In the selection of cereal breakfast foods the consumer may be guided by the results of analyses of disinterested chemists, by the digestibility as determined by actual tests, by cost, by taste, by economy, or by the observed effects of the goods upon individuals. It seems fair to conclude that the chemical composition, considered in connection with digestibility and cost, furnishes a satisfactory guide for selection, due attention being paid to palatability and individual preferences.

All things considered, the cereal breakfast foods as a class are nutritious, convenient, and reasonably economical foods and worthy of an important place in the diet when judiciously combined with other foods.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.

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